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Complex Light

Feature issue of Optical Engineering

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Publication date:
2015

Document Version
Publisher's PDF, also known as Version of record

Link back to DTU Orbit

Citation (APA):
Andrews, D. L., Galvez, E. J., & Glückstad, J. (Eds.) (2015). *Complex Light: Feature issue of Optical Engineering*. SPIE - International Society for Optical Engineering. Optical Engineering

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Complex Light

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The study of light with complex structured wavefronts, polarization profiles, and phase landscapes has become a remarkable focus of research in modern optics. It is striking how the complexity of the field itself has grown since the subject first gained prominence—and salutary to be reminded that simple Laguerre-Gaussian and Bessel beams were featured as long ago as 1991 in Saleh and Teich's milestone textbook *Fundamentals of Photonics*.[1] By a variety of means it is now possible to produce a wide range of beams of essentially nondiffractive, or apparently accelerating character, or others that exhibit phase singularities, a capacity to convey widely ranging quantities of orbital angular momentum, or a spatially varying polarization. This special section of *Optical Engineering* aims to convey some of the rapid recent advances in theory and experiment in this area—also highlighting a variety of applications that are already beginning to emerge.

'Accelerating beams' graphically defy the constraints of conventional optics, and Kotlyar et al. provide remarkable results that exhibit light fields with power circulating about a ring. Rumala's beautiful research shows the propagation of counter-rotating 'optical vortices,' achieved after multiple reflections in a spiral phase plate, while Ruffato et al. use similar optical elements to generate multiring beams whose orbital angular momentum suggests security hologram applications. With detection methods having notably lagged behind the advances in complex beam production, it is encouraging to see Huang et al. describe a clever new method for detecting and identifying phase singularities in optical vortices. Khajavi and Galvez describe studies using spatial modes with high-order topological charges to encode intricate patterns of polarization and their associated singularities, showing once again how it is possible to engineer optical beams with additional information. Naidoo et al. report the use of a monolithic microchip laser to directly produce vector polarization beams, suggesting that radially polarized beams could find applications in fiber injection, materials processing, and simulating quantum processes. Complex light fields offer unprecedented control for probing and exerting forces on matter on the microscale, and Villangca et al. achieve ultrafine spatial control through the active manipulation of extended microtools—optically trapped waveguide structures that are fabricated by two-photon photopolymerization. Soskind et al. show how anamorphic optical systems can be employed to engineer a variety of novel, propagation-invariant laser beams, exhibiting structured fields with various shapes and phase distributions, while Vijayakumar and Bhattacharya's contribution describes a compact diffractive optical element to generate superposed Bessel beams for optical trapping applications.

We thank all of these authors for contributing to this special section, and the reviewers for timely and helpful, incisive reports. The result is a showcase of modern optics.

References

1. B. E. A. Saleh and M. C. Teich, *Fundamentals of Photonics*, Wiley, Hoboken, New Jersey (1991).

David Andrews leads nanophotonics research at the University of East Anglia. He has over 300 research papers and sixteen books to his name, including recent volumes on *Structured Light and Its Applications*, and *The Angular Momentum of Light*. He is a Fellow of the Royal Society of Chemistry, Fellow of the Institute of Physics, and Fellow of SPIE. He is a member of the Board of Directors of SPIE and chairs its symposia committee.

Enrique (Kiko) Galvez is a professor of physics and astronomy at Colgate University, Hamilton, New York. He has published on classical and quantum aspects of complex light. He also publishes in physics education and is coauthor of three textbooks. He received the 2010 Prize to a Faculty Member for Research at an Undergraduate Institution from the American Physical Society. He has been chair and co-chair of the Complex Light and Optical Forces SPIE conference series.

Jesper Glückstad is professor, PhD, and DSc at DTU Fotonik, and was a guest professor in biophotonics at Lund Institute of Technology from 2006 to 2011. He established the Programmable Phase Optics group (www.ppo.dk) and received the Danish Optical Society Award in 2000 and was elected Scientist of the Year in 2005 by Dir. Ib Henriksen's Foundation in Denmark. He is a Fellow of the OSA and a Fellow of SPIE. He founded OptoRobotix.com in 2011, and most recently GPCphotonics.com.

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